

# Low-Cost Automated Irrigation System for Sustainable Home Gardening

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AFFILIATIONS



BEACH  
SUSTAINABILITY



## 01 ABSTRACT

This project presents a low-cost, solar-powered irrigation system designed to support sustainable plant care for individuals with limited time. Inefficient manual watering often leads to water waste and inconsistent plant health [1], highlighting the need for automated and resource-efficient solutions. The system integrates an Arduino Uno, soil moisture sensor, relay-controlled pump, and a solar-powered battery management system to automate watering based on real-time soil conditions. A display module provides user feedback, while a current sensor enables monitoring of energy usage. Results demonstrate improved water efficiency and consistent irrigation compared to manual methods. By combining automation with renewable energy, this project promotes sustainable gardening practices and reduces environmental impact [4]. The system is designed to be affordable and accessible, supporting broader adoption in underserved communities and encouraging environmentally responsible behaviors [5].

## 02 BACKGROUND

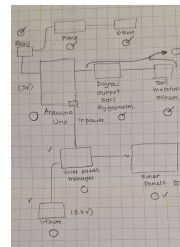
Water scarcity and inefficient irrigation practices are increasing concerns, especially in urban environments where time and resources are limited. Traditional watering methods often result in overwatering, wasted resources, and inconsistent plant growth. Sustainable solutions that integrate automation and renewable energy can address these challenges by improving efficiency and reducing environmental impact. [2]

Small-scale irrigation systems powered by solar energy offer a practical way to conserve water while minimizing reliance on grid electricity [3]. By incorporating sensors and microcontrollers, these systems can respond dynamically to plant needs, ensuring optimal water usage and promoting healthier plant growth.

## 03 METHODOLOGY

- Designed a solar-powered irrigation system using a lithium battery and solar panel for energy supply
- Integrated an Arduino Uno to control system operations
- Used a soil moisture sensor to measure real-time soil conditions
- Programmed the system to activate a pump via a relay when soil moisture falls below a threshold
- Implemented a display module to provide system feedback
- Included a current sensor to monitor energy consumption
- Evaluated system performance through testing and simulation of water flow and efficiency

## 04 INITIAL DESIGN



Component	Description	Qty	Unit Cost (\$)	Total (\$)
Arduino Uno R3	Microcontroller for system control	1	30.29	30.29
Pump + Relay + Sensor + Tubing	Includes DC pump, relay module, soil moisture sensor, tubing	1	9.99	9.99
Lithium-Ion Battery	3.7V 5200mAh rechargeable battery	1	19.73	19.73
Solar Power Manager	5V Li-ion charging + regulation module	1	16.9	16.9
Solar Panel Kit	5V 200mA photovoltaic panels (5 pack)	4	15.99	4.00
ST7735 Display	1.44" SPI TFT LCD display module	1	7.88	7.88
INA219 Current Sensor	I2C current/power monitoring module	2	6.99	3.50
	TOTAL:			92.28

Figure 1: The initial design consists of a solar-powered automated irrigation system controlled by an Arduino Uno. A soil moisture sensor monitors plant conditions and triggers a relay-controlled pump to deliver water when needed, ensuring efficient and consistent irrigation. The system is powered by a lithium-ion battery with solar charging, and includes a display and current sensor for real-time monitoring and energy tracking. The Bill of Materials (BOM) on the right summarizes the key components and demonstrates the system's cost-effective and accessible design.

## 05 SCHEMATIC

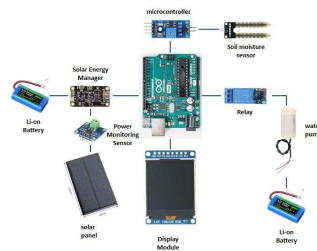


Figure 2: The schematic shows the system architecture, including the microcontroller, soil moisture sensor, relay-controlled pump, and solar-powered energy system, along with monitoring components for performance and status.

## 06 SIMULATION MODEL

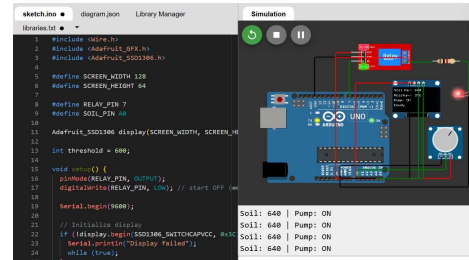


Figure 3: The simulation model demonstrates the system's functionality by integrating the Arduino Uno with a soil moisture sensor, relay module, pump, and display. The programmed logic activates the pump when soil moisture falls below a defined threshold, as shown by real-time serial and display outputs. This simulation validates the system's control strategy and confirms reliable automated irrigation behavior before physical implementation.

## 07 TEST

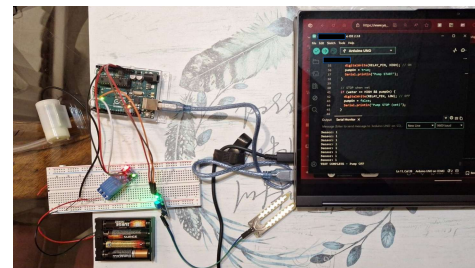


Figure 4: The first test validates the functionality of the automated irrigation system using a breadboard prototype controlled by an Arduino Uno. The soil moisture sensor successfully detects moisture levels and triggers the relay to activate the pump based on programmed thresholds. This initial setup confirms proper integration of hardware components and control logic, demonstrating the system's ability to perform automated watering in a real-world configuration.

## 08 CONCLUSION

The developed system successfully automates plant irrigation while improving water efficiency and reducing user effort. By using soil moisture feedback, the system minimizes overwatering and ensures consistent plant care. The integration of solar power enhances sustainability by reducing dependence on external energy sources. Overall, the project demonstrates a practical and scalable solution for sustainable gardening that can be widely adopted.

## 09 FUTURE WORK

- Integrate advanced soil moisture calibration for different plant types
- Develop a fully enclosed, weather-resistant system for outdoor use
- Optimize energy efficiency through improved power management
- Expand to multi-plant irrigation networks with independent control zones
- Implement wireless monitoring and data tracking (IoT integration)
- Enhance user interface on the display for real-time diagnostics

## 10 SUSTAINABILITY

- ➔ **Water Conservation:** Reduces water waste through sensor-based irrigation
- ➔ **Renewable Energy:** Solar-powered system reduces grid dependence
- ➔ **Climate Impact:** Supports local gardening and lowers emissions
- ➔ **Accessibility:** Low-cost design suitable for a wide range of users

## 11 REFERENCES

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