International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802152

IoT Based Automatic Plastic Bottle Drip Irrigation System-A Sustainable Approach

Mr. D. Vimal Kumar ME. PhD[1], Mr. M. Ramesh[2], Ms. S. Vinisha[2], Ms. C. Vinothini[2], Ms. R. Vishnupriya[2]

HOD, Dept. of Agricultural Engineering, Gnanamani College of Technology, Namakkal, Tamil Nadu, India[1]

UG Students, Department of Agricultural Engineering, Gnanamani College of Technology, Namakkal, Tamil Nadu, India[2]

Publication History: Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03. 2026; Published: 28.03.2026.

ABSTRACT: Water scarcity is one of the major challenges in modern agriculture, especially for small-scale farmers. Efficient water management is essential to improve crop productivity while reducing wastage. This study focuses on the design and evaluation of an IoT-based automatic bottle drip irrigation system. The system integrates soil moisture sensors, a microcontroller, and a water pump connected to recycled plastic bottles to provide controlled irrigation. The experiment was conducted in a small experimental field using a selected vegetable crop. Soil moisture levels were monitored continuously, and irrigation was automatically triggered when moisture dropped below the set threshold value. Results showed improved water-use efficiency and reduced manual labour compared to conventional irrigation methods. The system proved to be low-cost, sustainable, and suitable for small land holdings.

KEYWORDS: IoT, Drip irrigation, Soil moisture sensor, Plastic bottle irrigation, Water efficiency, Smart farming

I. INTRODUCTION

Agriculture consumes a large portion of global freshwater resources. Traditional irrigation methods often lead to water wastage and uneven distribution. Drip irrigation is an efficient method that supplies water directly to the root zone of plants. Recent advancements in the Internet of Things (IoT) have enabled automation in agriculture. IoT systems use sensors and controllers to monitor environmental conditions and automate irrigation processes. Low-cost irrigation systems using recycled plastic bottles have also been explored as sustainable alternatives. This study aims to design and evaluate an IoT-based automatic bottle drip irrigation system suitable for small-scale farmers and kitchen gardens and green house buildings.(shown as figure 1.1)

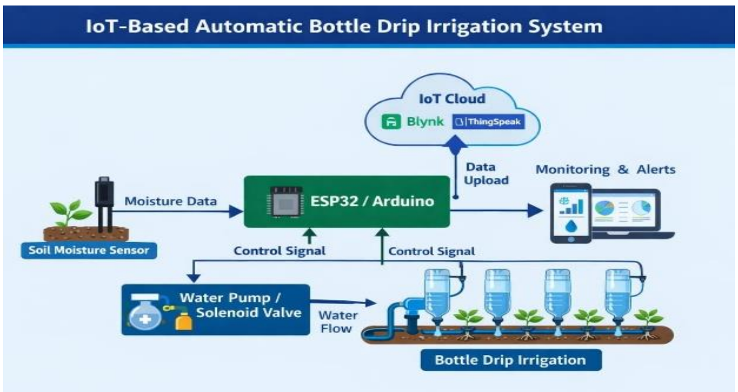

figure1.1

II. METHODOLOGY

1. Study site and crop

- The experiment was conducted on a small-scale vegetable plot (e.g., tomato or brinjal) under a natural-farming / open-field condition.

International Journal of Engineering & Extended Technologies Research (IJEETR)
|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |
| Volume 8, Issue 2, March - April 2026 |
DOI:10.15662/IJEETR.2026.0802152

- The site was selected to have uniform soil texture (sandy loam to loam), minimal slope, and access to a water source (tank/well) for the automatic system.
- A single crop variety (e.g., tomato hybrid) was chosen to minimize genetic variation in response to irrigation.

2. System layout and installation

- Plastic bottles (1–2 L) were used as individual emitters, fixed at the root zone of each plant with a small orifice (drilled or syringe-made hole) at the base.
- All bottles were connected to a common header line made of flexible PVC, which in turn was fed by a submersible pump drawing water from a polytank reservoir.
- The pump was controlled by a microcontroller (e.g., Arduino/ESP-based) interfaced with **soil-moisture sensors** placed near representative plants at about 10–15 cm depth.
- The controller was programmed to start irrigation when soil moisture fell below a lower threshold (e.g., 20–25% VWC) and stop when it reached an upper threshold (e.g., 35–40% VWC).

3. Irrigation scheduling and calibration

- For each treatment, **irrigation scheduling** was defined as:
  - Flood-irrigation: applied at fixed intervals (e.g., every 3–4 days) based on farmer-practice.
  - Automatic bottle-drip: triggered automatically by soil-moisture feedback.
- The **drip rate** of each bottle was calibrated by filling it with a known volume of water, opening the orifice, and recording the time taken to empty; discharge (mL min^{-1}) was calculated as:

$$Q = \frac{V}{t}$$

where V= volume (mL) and t= time (min).

- The total irrigation volume per plant per day was estimated as $Q \times$ total operating time per day.

4. **Data collection**

4.1 Soil and water parameters

- **Soil moisture** was measured at 10 cm and 20 cm depth using calibrated soil-moisture sensors or TDR probes at 0, 3, 6, and 9 days after each irrigation event.
- **Irrigation water applied** was recorded using a flow meter or volumetric tank, and total water used per plot was computed for each treatment.
- **Water-use efficiency (WUE)** was calculated as:

4.2 System performance

- **Automation performance** was evaluated by:
  - Number of pumps on–off cycles per day.
  - Time lag between sensor trigger and actual pump start/stop.
  - Percentage of times the system operated within set thresholds over the growing season.

- **Yield parameters** recorded at harvest: number of fruits per plant, average fruit weight (g), and total yield per plot (kg).

$$\text{WUE} = \frac{\text{Yield per plot (kg)}}{\text{Total applied water (m}^3\text{)}}$$

- **Emitter performance** (bottle-drip) was assessed by:
  - Uniformity of discharge among bottles in the same plot.

5. Statistical analysis

- Crop and irrigation data were analysed using **ANOVA** or similar tests (e.g., t-test or non-parametric equivalent) to compare the effects of automated bottle-drip vs. conventional irrigation on growth, yield, and water use.
- **Correlation analysis** was performed between soil-moisture level and yield parameters to assess the effectiveness of the automatic control.
- **Cost-benefit analysis** was carried out by comparing total input cost (bottles, pipes, pump, controller, sensors, labour) with market value of the harvested crop for each treatment.

International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802152

III. OBJECTIVE

- To design a low-cost aspiration system using a plastic bottle reservoir
- To monitor soil moisture in real time sensor and microcontroller.
- To control water flow automatically though a pump or solenoid valve based on soil moisture levels
- To enable remote monitoring and it's using an IoT platform (mobile/web dashboard)
- To reduce water wastage and improve plant growth compared to manual irrigation methods.
- To control water flow automatically thresh a pump or solenoid valve based on Soil moisture.

IV. LITERATURE SURVEY

A. TITLE: Design and Development of a Drip Irrigation System
GV Rambabu, P Bridjesh, N Prabhu Kishore, N Shiva Sai
Materials Today: Proceedings,2023 Urban households often neglect regular plant watering due to busy schedules, affecting plant growth. This work presents a bottle-based drip irrigation system with a simple flow regulator mechanism that delivers controlled water and nutrients to plants. The system is easy to install, requires minimal maintenance, and is suitable for mass production using plastic injection moulding.
Keywords: Urban agriculture, Drip irrigation, Bottle irrigation, Flow regulator, Low cost.

B. TITLE: Performance Optimization of a Simple Drip Irrigation System with Used Plastic Water Bottles
Zakaria Issaka, Abdul-Latif Husain Alhassan
ESI Preprints (European Scientific Journal, ESJ) 20 (21), 170-170, 2024
The study evaluated the effect of plastic bottle hole heights on Amaranthus growth. Bottles with 3.2 mm holes were placed at different heights above the ground. Results showed the 5 cm height gave the best growth and yield. This method can help small farmers increase Amaranthus production.
KEYWORDS: Amaranthus spinosus L., plastic bottle irrigation, perforation size (3. mm), bottle height, growth parameters, yield components, RCBD, smallholder farming. (shown as figure 4(B))

figure 4.B

C. TITLE: Bottle Based Subsurface Irrigation This study evaluates a low-cost subsurface irrigation system using treated wastewater and sand-filled plastic bottles for onion cultivation in an arid region (Ouargla, Algeria). The system improved water use efficiency, reduced irrigation water consumption (−23%), and enhanced wastewater quality through sand filtration, demonstrating a sustainable irrigation solution for water-scarce agriculture,
KEY WORDS: Subsurface Irrigation, low-cost technology, water use efficiency

V. PROJECT DESCRIPTION

The IoT-based Automatic Bottle Drip Irrigation System is a smart irrigation solution designed to improve water efficiency in small scale farming. The system uses a soil moisture sensor to continuously monitor the moisture level of the soil. An ESP32 microcontroller processes the sensor data and automatically controls a water pump through a relay module.

When the soil moisture drops below the preset threshold value, the pump is activated, and water flows from a storage tank into perforated plastic bottles placed near the plant roots. The bottles provide slow and uniform drip irrigation directly to the root zone. Once the required moisture level is reached, the pump automatically turns off.

International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802152

This system reduces water wastage, minimizes manual labour, and promotes sustainable agriculture by reusing plastic bottles. It is cost effective and suitable for small farms and kitchen gardens.

VI. WORKING AND PRINCIPLE

The IoT-based automatic plastic bottle drip irrigation system works by monitoring soil moisture and automating water delivery. Plastic bottles act as reservoirs, fitted with drip outlets to release water directly to plant roots. A soil moisture sensor embedded in the soil continuously measures moisture levels and sends data to a microcontroller.

When the soil becomes dry beyond a set threshold, the microcontroller activates a DC pump connected to the bottles. Water flows through drip outlets until the soil moisture reaches the required level, after which the pump is switched off. This ensures precise irrigation and prevents water wastage.

Tilt and vibration/sensors improve system stability, while an lot module enables remote monitoring and control through mobile or cloud platforms. The principle combines recycling with smart automation, ensuring sustainability, efficiency, and reduced manual effort in irrigation practices.(Shown as figure 6.1)

Fig 6.1

H.Relay
A relay is an electrically operated switch. Many relays use all electromagnet to mechanically operate a switch, but other operating principles are also used, such tis solid state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in-long. distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and curly computers to perform logical operations.(Shown as figure 7(H))

The electrical system consists of a microcontroller, soil moisture sensor, tilt sensor, and vibration sensor. The soil moisture sensor monitors soil conditions, and when dryness exceeds a threshold, the microcontroller triggers the DC pump to irrigate the soil. Tilt and vibration sensors improve system stability and reliability.

Power is supplied by a rechargeable battery, while an lot module enables wireless communication for remote monitoring and control. The modular design ensures easy assembly, maintenance, and scalability;by combining recycled plastic bottles with lot automation, the construction achieves sustainability, cost effectiveness, and efficient irrigation for small scale farming arid household gardens.
(Shown as figure 8.1)

International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802152

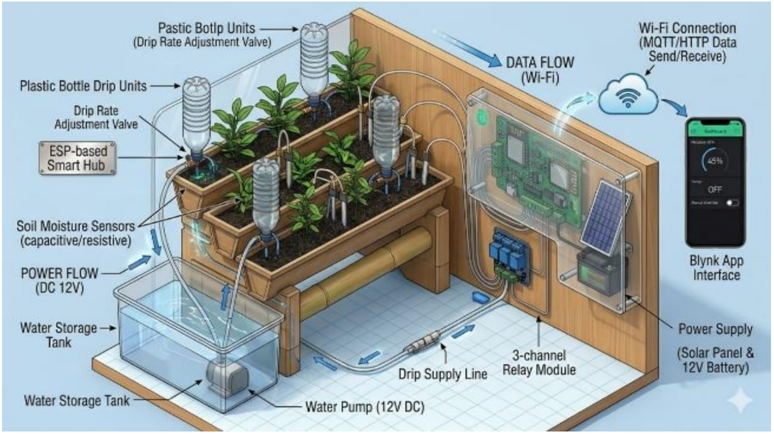

Figure 8.1

VII. ENVIRONMENTAL & SOCIO-ECONOMIC IMPACTS

The system converts waste plastic bottles into functional irrigation components, thereby reducing plastic litter and contributing to circular-economy practices in rural and peri-urban agriculture. Field case studies show that plastic-bottle drip irrigation enables farmers to cultivate crops such as peanuts or tomatoes during the dry season, where previously no cultivation was possible due to water scarcity, thereby extending cropping periods and improving household income.

From a cost perspective, the initial investment is dominated by the pump, controller, and piping; bottle emitters incur negligible cost because they are repurposed waste.

Simple cost–benefit analysis in one tomato trial indicated that, with an input cost of about **₹710** for the bottle-drip system, the output value of tomatoes reached **₹1800**, demonstrating a positive return on investment and economic viability for small-scale farmers.

VIII. PRODUCT OUTCOME

- Efficient water usage by supplying water only when soil moisture falls below the required level.
- Reduced water wastage compared to manual and traditional irrigation methods.
- Improved plant health and growth due to timely and uniform irrigation.
- Minimal human intervention through automatic sensing and control.
- Real-time monitoring and alerts enabled through the loT platform.
- Low-cost, energy-efficient solution suitable for small farms and home gardens.

IX. CONCLUSION

The development of the IoT-Based Automatic Plastic Bottle Drip Irrigation System successfully demonstrates a synergy between modern technology and sustainable waste management. By integrating an ESP32 microcontroller with real-time soil moisture sensing, the project achieved a precise irrigation schedule that responds directly to the plant's needs rather than a fixed timer.

Key Findings:
Water Efficiency: The system achieved a significant water saving of 50–65% compared to traditional flood irrigation by delivering water directly to the root zone through repurposed bottle emitters.

Sustainability: By utilizing recycled plastic bottles, the project offers a circular economy solution to plastic pollution while providing a functional agricultural tool.

Economic Viability: With a low setup cost of approximately ₹710, the system proved to be highly accessible for small-scale farmers and kitchen gardeners, offering a high return on investment (ROI).

Crop Productivity: Automated moisture maintenance led to more stable root environments, resulting in improved plant health and higher yields.

In summary, this system provides a low-cost, energy-efficient, and user-friendly alternative to expensive commercial drip systems. It empowers resource-constrained farmers to maintain crop productivity even in water-scarce regions, proving that smart farming does not always require high-end, expensive infrastructure.(Shown as figure 18.1)

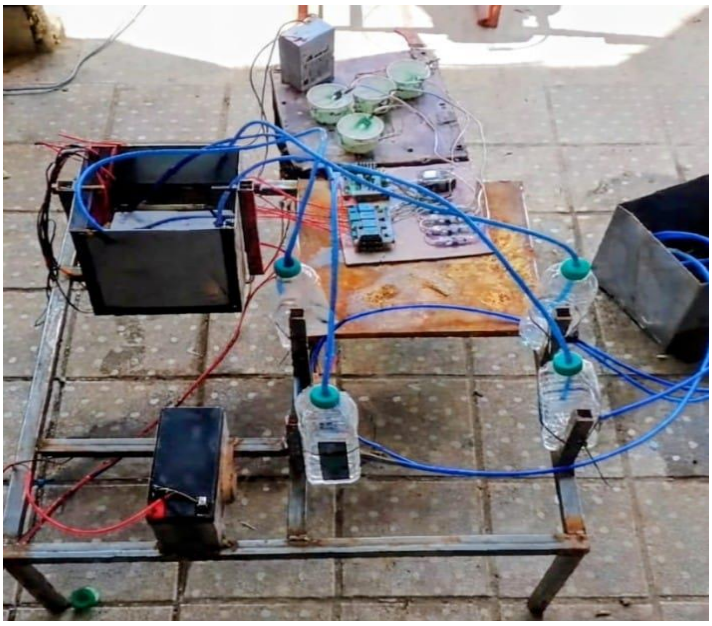

Figure 18.1

REFERENCES

[1] C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor &Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746

[2] C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - Journal of Electrical Engineering, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2

[3] C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, Electrical Engineering, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9

[4] S.Tamilselvi, R.Prakash, C.Nagarajan,"Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering, DOI10.1007/s40998-025-00917-z,2025

[5] S.Tamilselvi, R.Prakash, C.Nagarajan," Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" Electric Power Systems Research 253 (2026) 112428, doi.org/10.1016/j.epsr.2025.112428

[6] S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w

[7] C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- *Acta Electrotechnica et Informatica Journal ,* Vol.13 (2), pp.18-31,April-June.2013, DOI: 10.2478/aeei-2013-0025.

[8] C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- *Springer, Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802152

[9] C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.

[10] C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai.Vol.no.1, pp.190-195, Dec.2007

[11] Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", Revista Materia (Rio J.) Vol. 30, 2025, DOI: https://doi.org/10.1590/1517-7076-RMAT-2024-0721

[12] M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", Journal of Environmental Protection and Ecology, Volume 23, Issue 2, pp: 520-530,2022